Cooperative Agreement Notice Mission Architecture Study

Facility Science Team Overview

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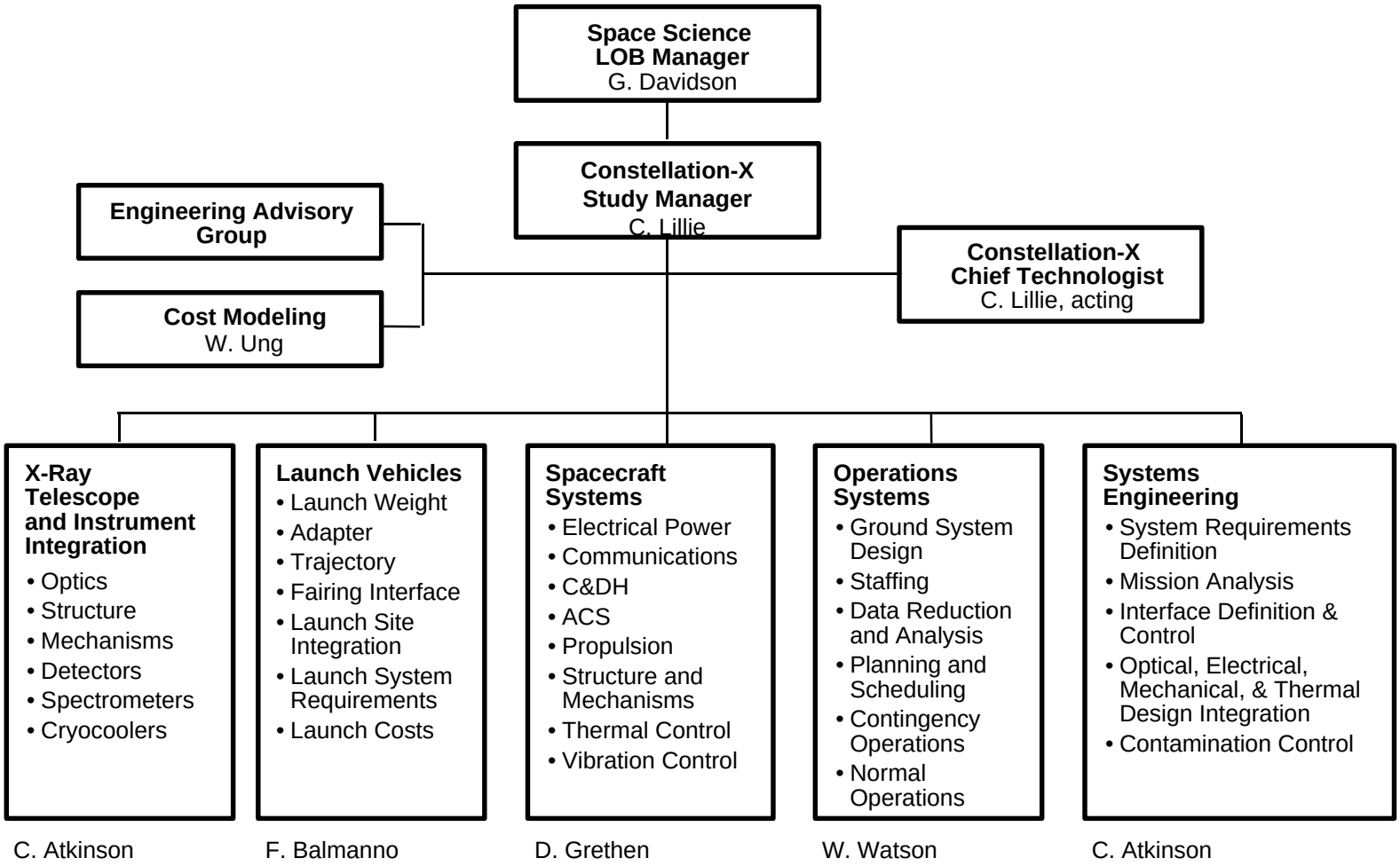
Topics

- Study Objectives
  - Location
  - Configuration
  - Cost
- Configurations Trades and Analyses
  - Process
  - Options and Selections
- Cost Estimates
- Key Technologies
- Summary

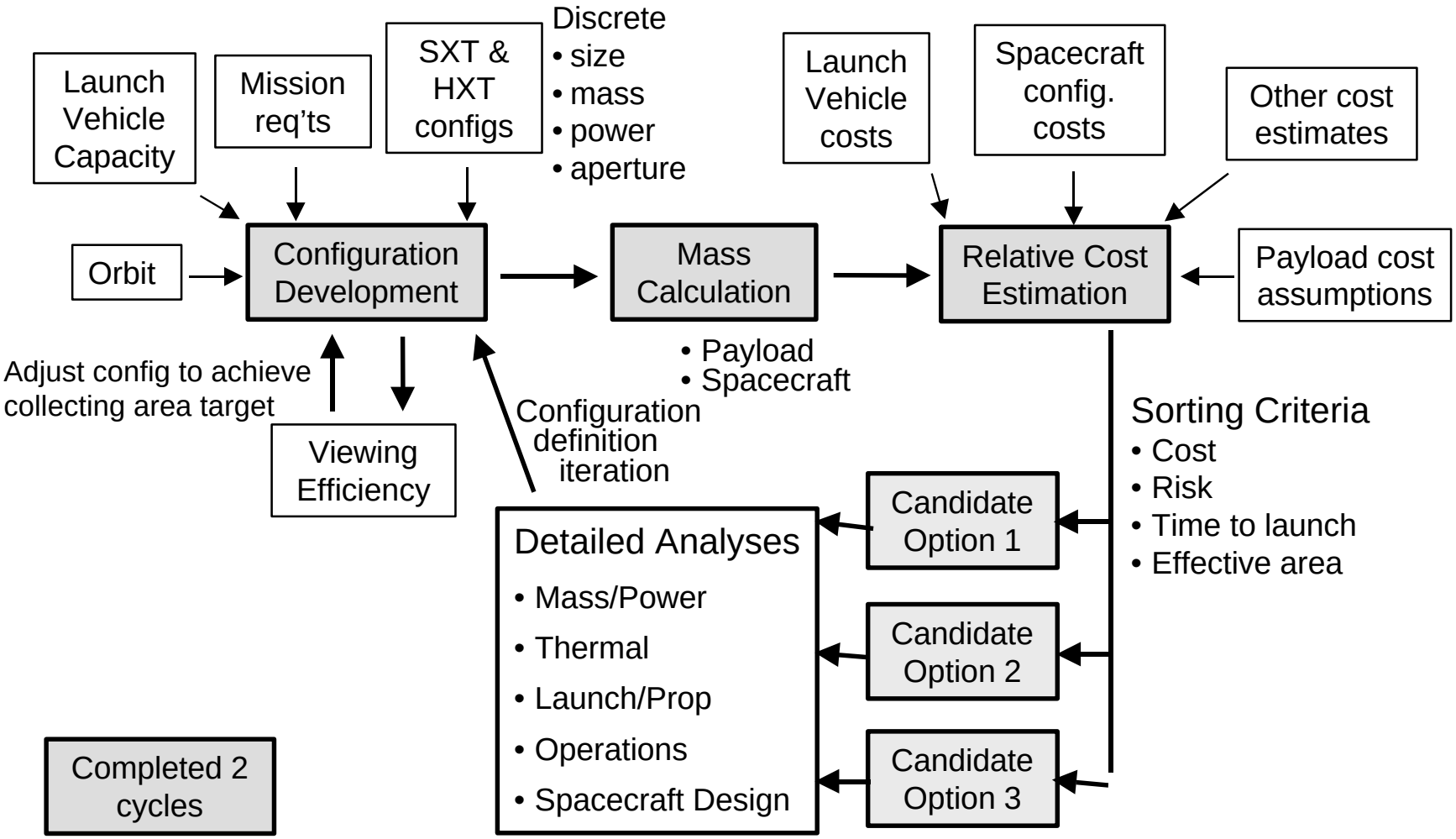
Study Organization



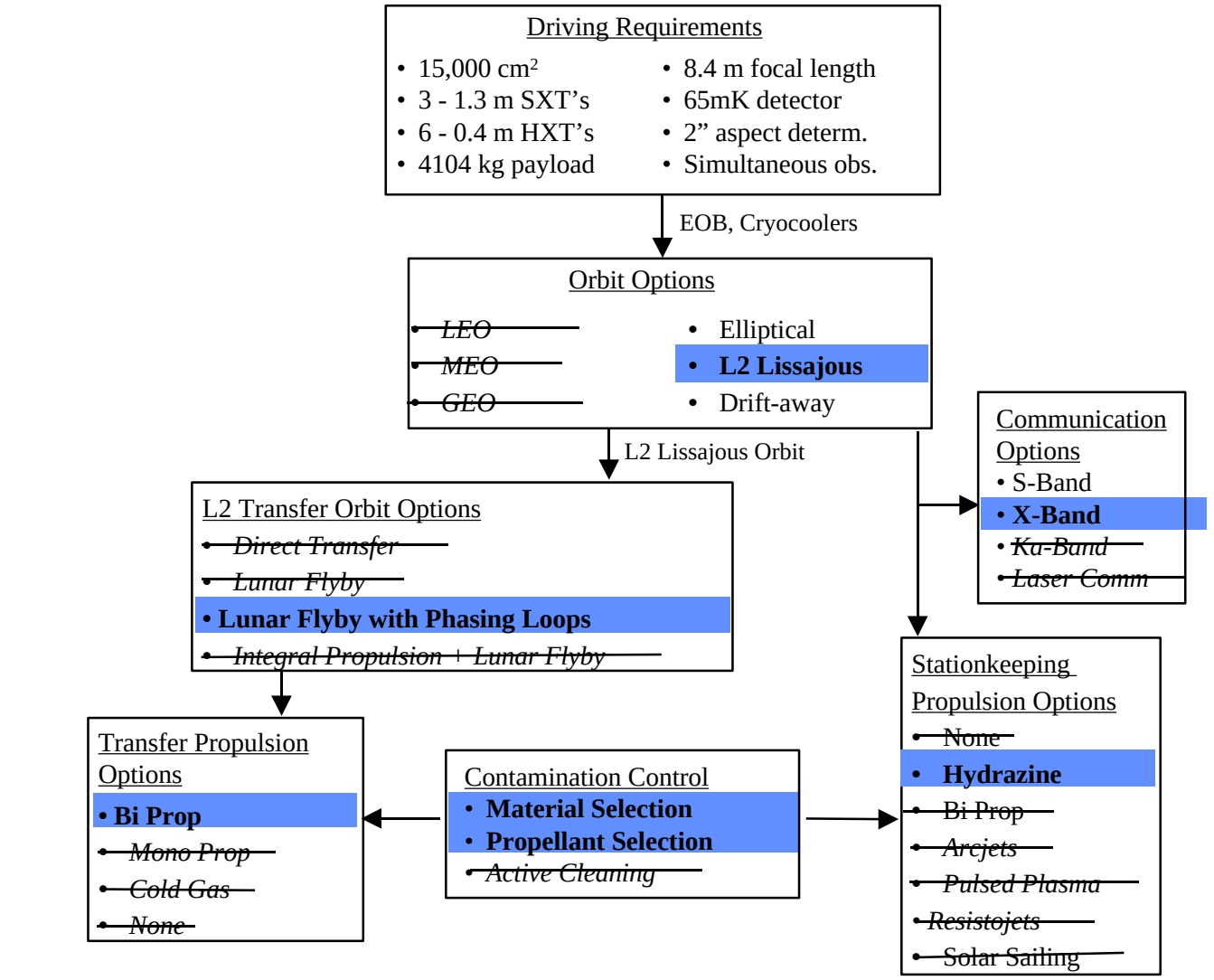
Configuration Trades

- Mission requirements derived from CAN and project office inputs
  - Large variety of SXT apertures (0.7 to 1.8 meters)
- Trade space included a wide range of orbits and launch vehicles
  - LEO, GEO, Elliptical, Driftaway, L2
  - Delta II, IV (small, medium, medium+), Atlas II, Zenit, Titan
- System life-cycle cost was the major criterion
  - Cost estimated for each element to compare design options
  - Launch costs dominate LCC
- Three design options selected for further study

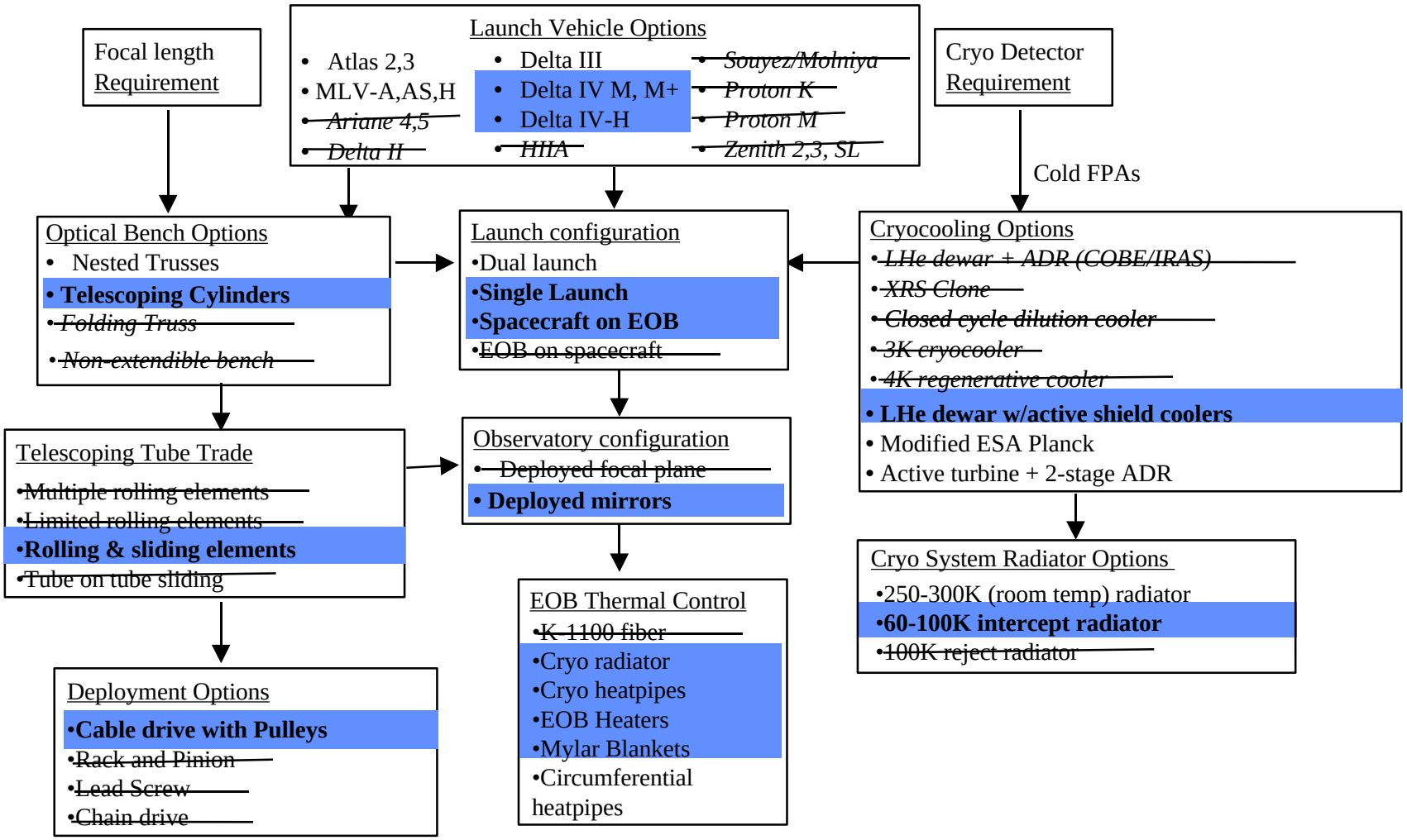
Configuration Trade Process



Trade Tree (1/2)



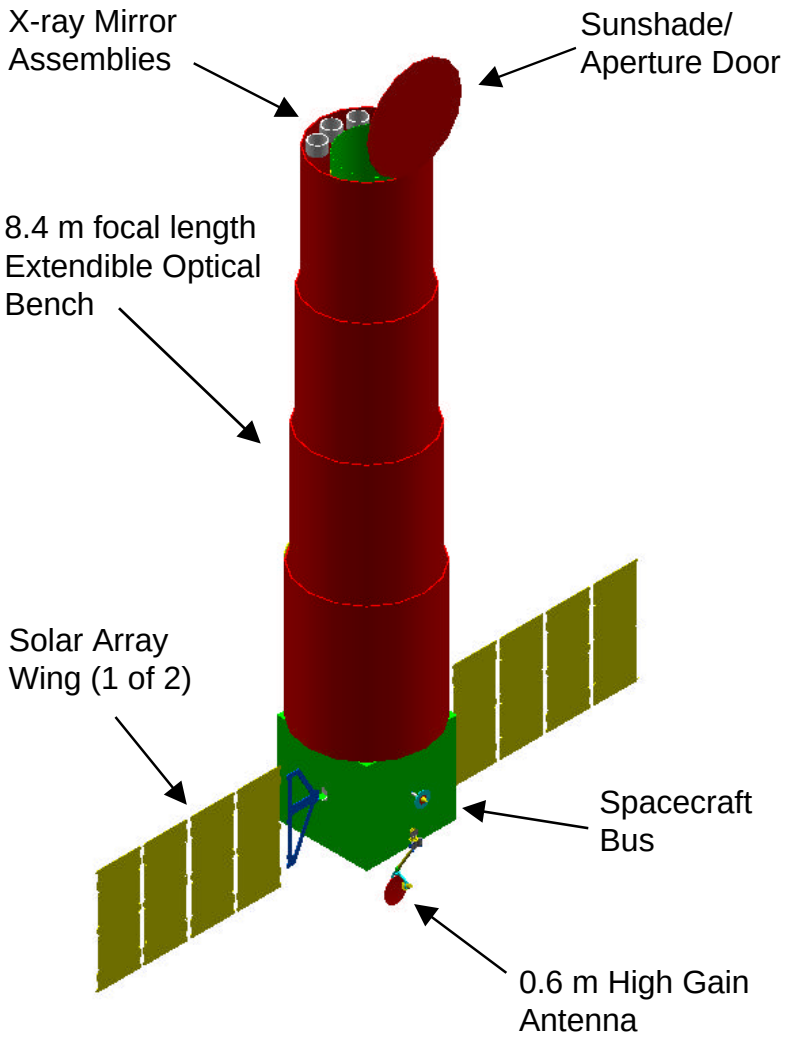
Trade Tree (2/2)



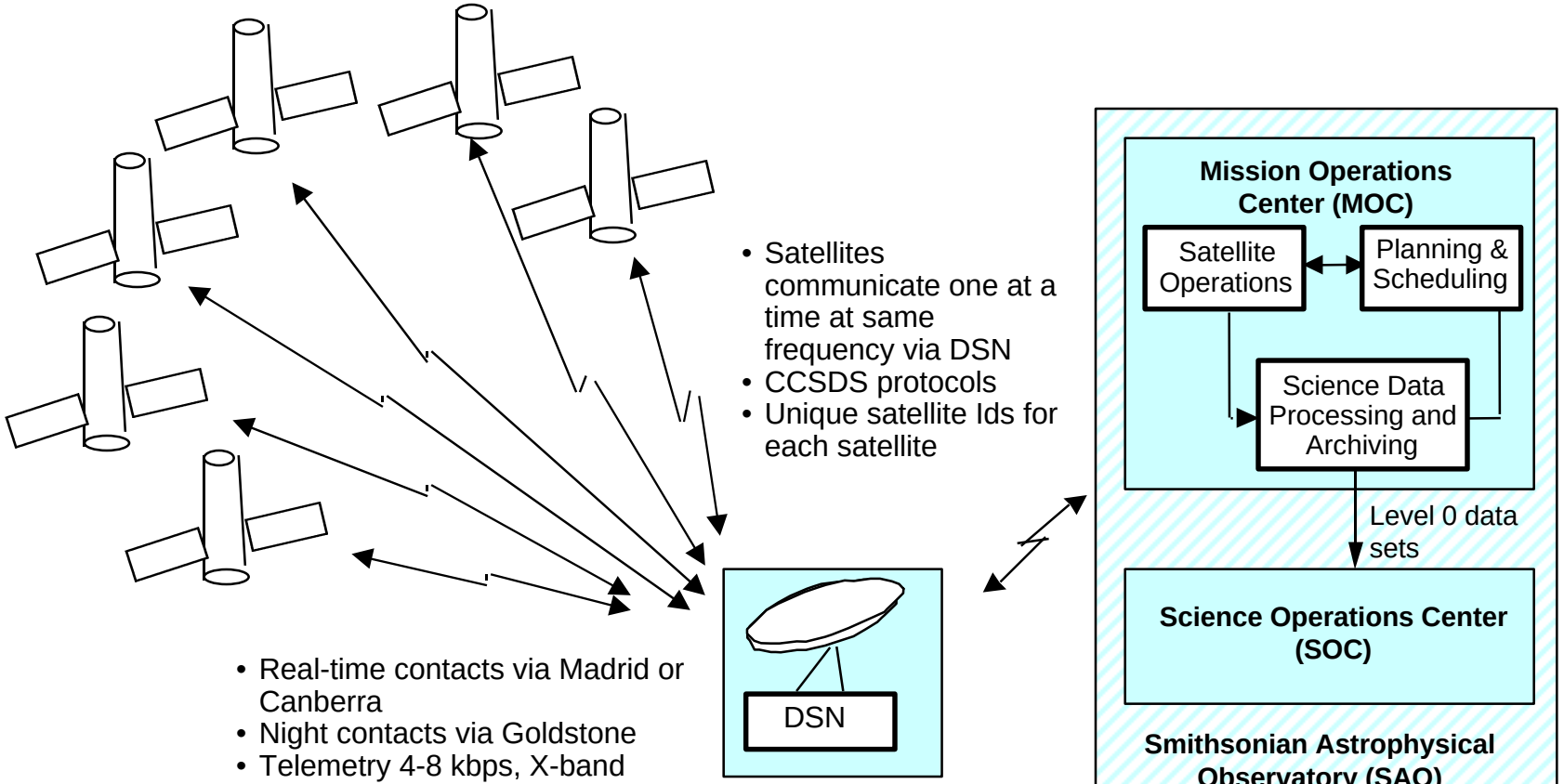
Observatory Configurations

- S/C in L2 or Driftaway orbit
- Launch on Delta-IV
- Spacecraft bus derived from GEOLITE satellite design
- 11-meter DSN(or dedicated) ground antenna for operations
  - 1024 kbps X-band downlink,
  - 2 kbps uplink
- Primary difference between configurations is the number of SXT's and HXT's per spacecraft:

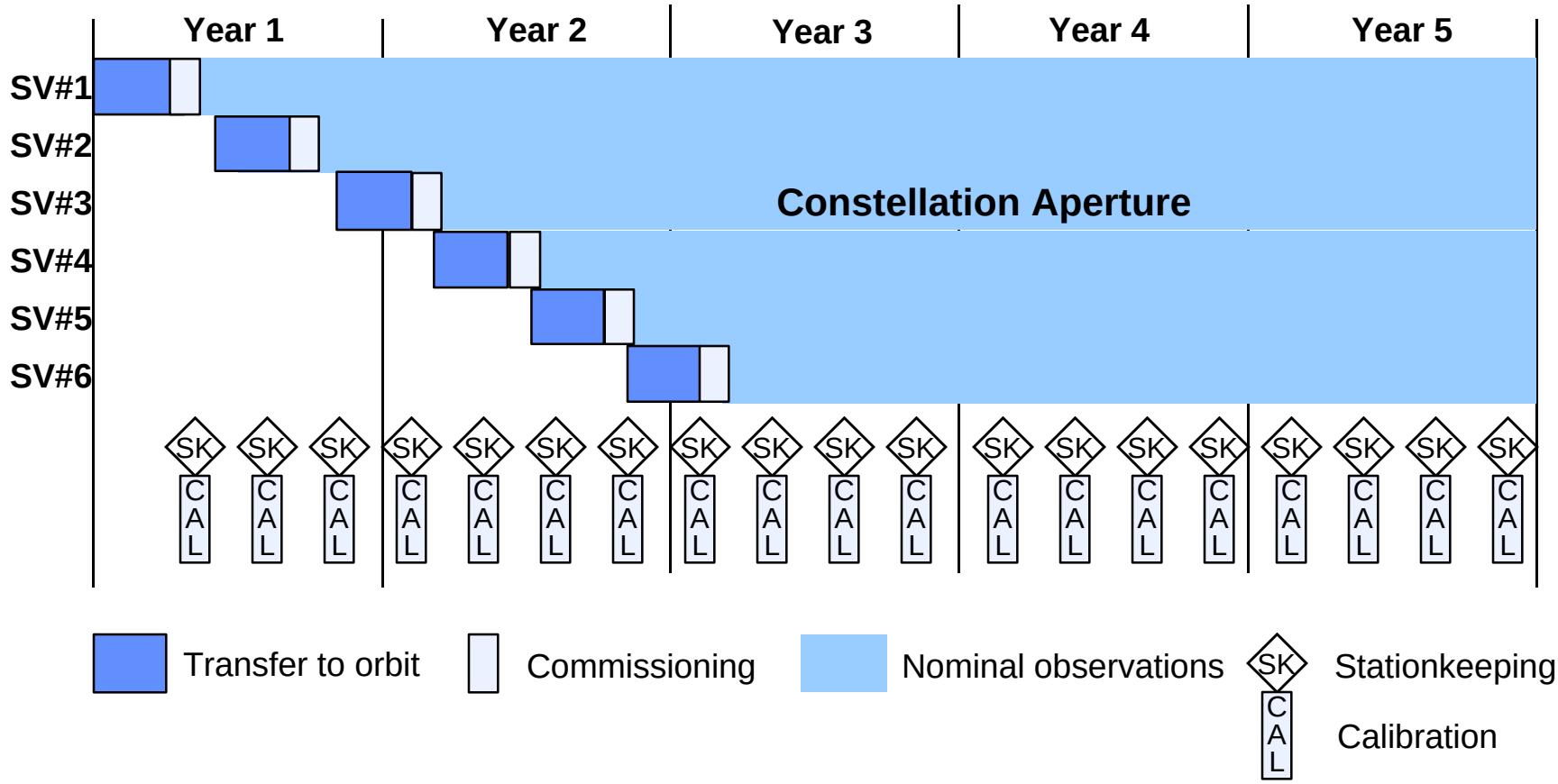
Config. No.	No. of S/C	No. of SXT's per S/C	No. of HXT's per S/C	Delta IV Launch Vehicle
1	6	1 - 1.3 m	3 - 0.28 m	Medium
3	3	2 - 1.3 m	4 - 0.4 m	Med-plus
4	2	3 - 1.3 m	6 - 0.4 m	Heavy



Operations Concept



The 5-Year Life of Constellation-X



Constellation X Cost Modeling

- The purpose of the CAN Study was to identify innovative solutions which satisfy top level science objectives at minimum cost
  - Target for the non-payload portion of Constellation-X was on the order of $300M (FY98$)
- TRW costs derived from parametric cost modeling analysis, as is appropriate to this phase of the program
  - Pre-phase A configurations are in an early stage of development
  - Launch vehicle costs presented are the best estimates currently available while the EELV competition is ongoing.
- Cost models used are grounded in the TRW experience with recent spacecraft manufacture, e. g. , GEOLITE and EOS
- Our modeling effort indicates a need for lighter and cheaper spacecraft/optical bench/payload, and/or more capable, cheaper launch vehicles

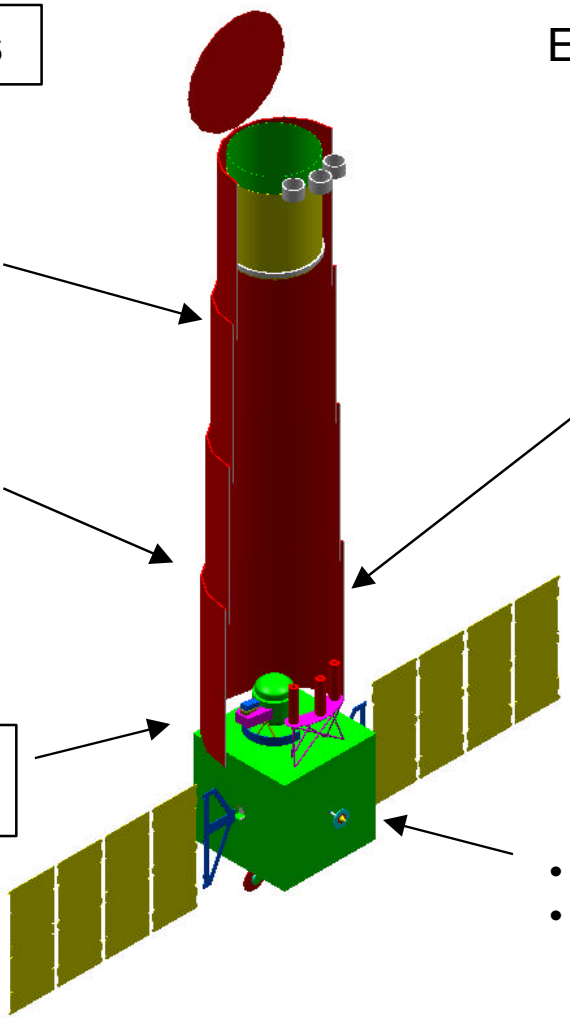
Key Non-Payload Technologies

Enabling Technologies

Extendible Optical Bench

Aspect Determination and Pointing Control System

Cryocooler system-active turbine + two stage ADR



Enhancing Technologies

Cryogenic Heatpipes/Radiators

Lightweight Solar Arrays

- Lightweight Batteries
- Advanced Avionics

Constellation-X Technology Development

- In the non-payload portion of the program, our candidates are divided between the spacecraft, operations, launch vehicles and the instrument module
- Spacecraft
  - Amorphous silicon solar arrays for low cost and weight
  - Lithium ion batteries for reduced weight
  - Advanced avionics to reduced spacecraft mass, power and volume requirements
- Operations
  - Common software and data base for unit test, system level test and mission operations
- Launch Vehicles
  - EELV technology development
  - Re-useable launch vehicle development

Constellation-X Technology Development II

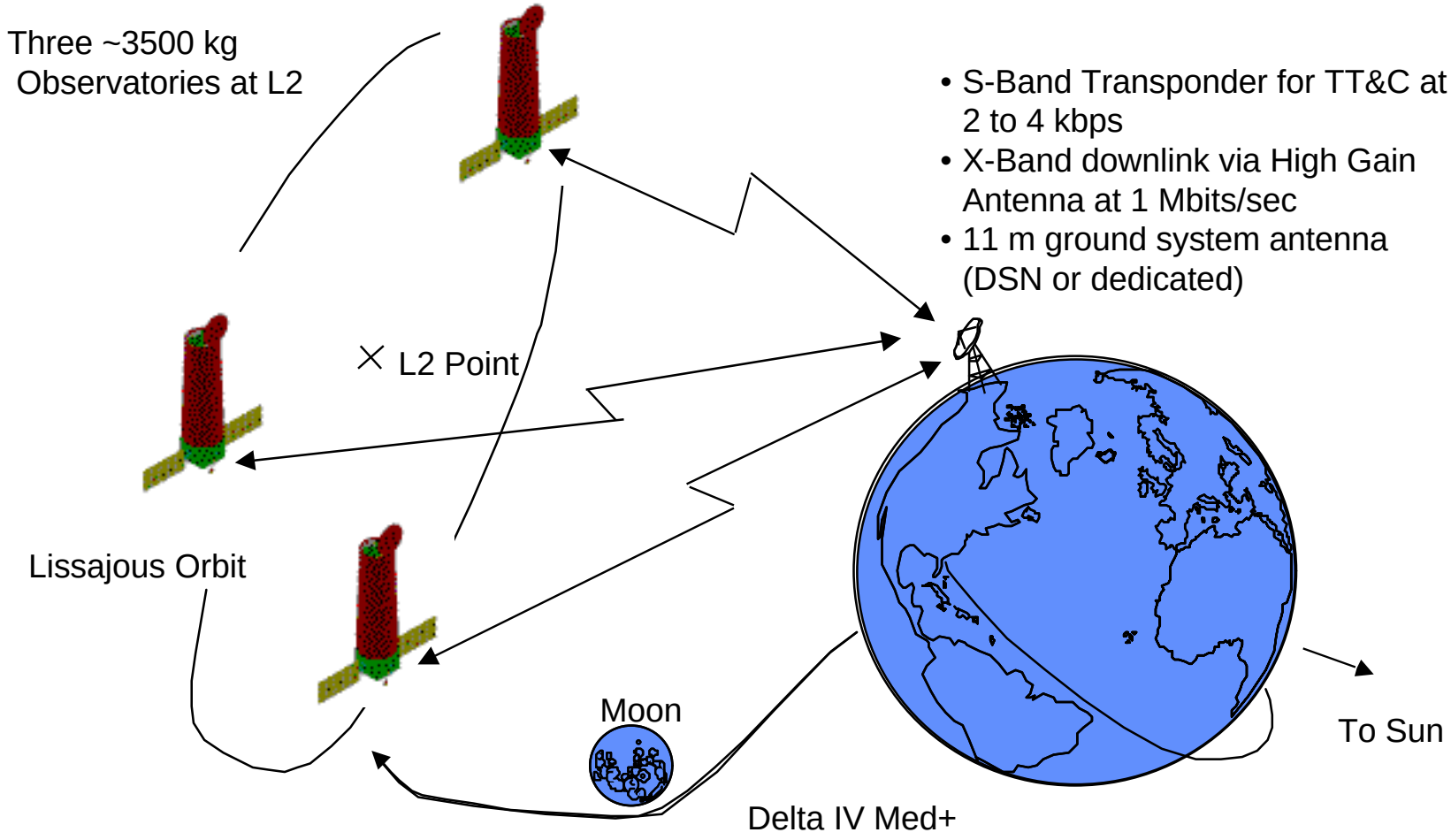
- Instrument Module
  - Affordable aspect Determination System
  - Extendible optical bench to reduce LV fairing volume requirements and meet center-of-gravity constraints
    - Ground testbed for proto-flight hardware demonstration
    - Structure, deployment mechanisms and latches
  - Advanced 2 stage cryocooler to reduce both mass and cost
  - Cryogenic radiator operating at ~100K

Summary

Completed $220K Pre-Phase A CAN feasibility assessment

- Trade space narrowed by top level trades
  - Orbits
  - Launch vehicles
  - Configuration options
  - Communications options
  - Cryocooling options
- Three design options identified and studied in additional detail
  - Subsystem design specified
  - Mass and power budgets developed
  - Thermal performance evaluated
- ROM cost estimate generated for each configuration
  - LCC costs for non-payload portion of Constellation-X
  - Cost based on parametric model, engineering estimates, launch vehicle manufacturer inputs and TRW cost data base

Mission Concept



Constellation-X Mission is Feasible

- Current mission costs are not consistent with $300M target for spacecraft/EOB, I&T, launch and operations
- High potential for cost reductions
  - LV/cost performance trends
  - Architecture options to reduce mass
  - Design synergistically with future production lines
  - Ongoing technology investments to reduce observatory mass and cost (industry and NASA cross-cut technologies)
  - Targeted Constellation-X investments to reduce cost and risk
    - Extendible Optical Bench
    - Cryocooler
    - Aspect determination system
    - Cryo Radiators, etc.

Future Work

- Continue to refine selected configurations to obtain robust design concepts
  - Subsystem trades
  - Payload interface definition
  - Launch vehicle interface
- Develop more complete concepts for integration and test, ground system and mission operations
- Use “Cost-As-an-Independent-Variable” methods to generate cost-effective designs
- Develop enabling technologies to reduce program cost and risk
  - EOB testbed with structure and deployment mechanisms, plus attitude determination and thermal control system components

Acronyms

ACS	Attitude Control System
ADR	Adiabatic Demagnetization Refrigerator
CAN	Cooperative Agreement Notice
CCSDS	Consultative Committee for Space and Data Systems
C&DH	Command & Data Handling
DSN	Deep Space Network
EELV	Evolved Expendible Launch Vehicle
EOB	Extendible Optical Bench
EOS	Earth Observing System
GEO	Geosynchronous Orbit
GTO	Geosyschronous Transfer Orbit
HXT	Hard X-ray Telescope
IPT	Integrated Product Team
I&T	Integration & Test
L2	Second Lagrangian Point
LEO	Low Earth Orbit
LCC	Life Cycle Costs
LOB	Line of Business
MEO	Medium Earth Orbit
MLV	Medium Launch Vehicle
MOC	Mission Operations Center
SAO	Smithsonian Astrophysical Observatory
SOC	Science Operations Center
SXT	Soft X-ray Telescope
TT&C	Telemetry, Tracking & Control